Using liquid heterogeneous catalysts to enable the production of fuels and chemicals without producing carbon dioxide

D. Chester Upham

About the projects

The promise of using hydrogen as a clean fuel lends evidence to the possibility of a decarbonised future. But if the use of hydrogen is to eventually meet the strictest environmental criteria, one must consider that the production of hydrogen currently produces significant amounts of carbon dioxide.

Most hydrogen is currently produced through steam methane reforming, a reaction between methane and steam. Done at high temperatures, this process produces hydrogen along with carbon dioxide. There are other cleaner ways of producing hydrogen, electrolysis being one. Also called water splitting, this process takes a lot of energy, making it cost intensive.

Cleaner and cost-effective ways of producing hydrogen are key interests for Dr. D. Chester Upham, Assistant Professor in UBC's Department of Chemical and Biological Engineering. One focus for his group is understanding liquid catalysts, which are used to increase the rate of chemical reactions.

"There is a huge wealth of knowledge from many decades of catalyst science," says Upham. "Most of that has all gone into understanding solid catalysts. There are applications of liquid catalysts that could be very beneficial for cleaner ways of producing hydrogen but we just don't have much information about how these liquid catalysts behave."

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"It's always really important to keep in mind that new technologies and new ways of producing fuels and chemicals need to also be affordable and cost competitive."

"If we can affordably make clean fuels and chemicals in environmentally friendly ways, then I think you can continue the prosperity of humankind while also not having the downsides of global warming."

- Dr. D. Chester Upham

Project Highlight:

UBC researchers are looking into the behaviour of liquid heterogeneous catalysts and their potential for helping produce clean fuel without creating carbon dioxide.

The Team:

- Dr. David Chester Upham, Assistant Professor in UBC's Department of Chemical and Biological Engineering
- Mark Tabbara, PhD student, Chemical and Biological Engineering
- Genpei Cai, PhD student, Chemical and Biological Engineering
- Chris Zong, Master of Engineering student, Chemical and Biological Engineering
- Anish Karnik, Master of Engineering student, Chemical and Biological Engineering

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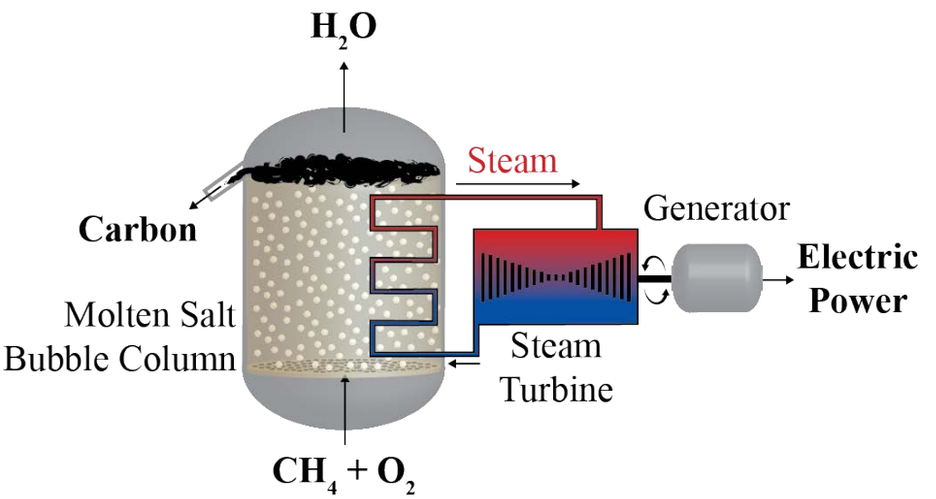
Upham's group is examining liquid catalysts in the context of methane pyrolysis, a potentially good way of making hydrogen. "Methane pyrolysis is a carbon dioxide-free method of making hydrogen without using as much energy as electrolysis and therefore could be an affordable alternative," says Upham.

One problem with methane pyrolysis is the use of solid catalysts during the production of hydrogen. Solid catalysts help reactions run faster and their use is standard practice in many industrial settings. During methane pyrolysis, however, a byproduct of the reaction builds up on the surface of the catalyst; gases can no longer interact with the catalyst and the solid mass eventually plugs the reactor.



"Using a liquid catalyst allows you to overcome these challenges when used in a bubble column. The less dense solid byproducts float to the surface and then can be skimmed off, so the catalyst doesn't deactivate and it doesn't plug up the reactor," says Upham.

Applications of liquid catalysts also extend to the production of syngas, a commonly used chemical intermediate when producing liquid fuels like gasoline or diesel.

Upham leads a heavily experimental group, making use of multiple reactors. They also conduct some process modeling and techno economic analyses, with the overarching goal of

contributing to new processes which could make clean fuels and chemicals in environmentally friendly ways.